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Detection of Intrinsic Optical Signals in the Somatosensory Cortex of Neonatal Rats by Principal Components Analysis

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Recording of the intrinsic optical signal (IOS) is widely used or functional studies of the cerebral cortex in vivo. Despite the fact that IOS provides for detection of active areas, regardless of the age of the object, it is widely used in studies of the developing brain. However, in immature brains IOS has low amplitude, which hinders its use and requires other recording and analysis methods. We report here our assessment of the use of the principal components analysis (PCA) method for the automatic detection of IOS at the early stages of development of the rat brain. Recording of IOS in infrared light and use of PCA was found to provide reliable detection of IOS in rats in the first three weeks after birth. Addition of artificial noise to IOS showed that detection using PCA was effective in half of cases despite increases in the noise level to four times baseline. These results provide evidence that the PCA method has potential to be used for detecting IOS at the early stages of development and that the PCA method is very robust for detection of IOS.

Keywords: cortex, intrinsic optical signal, principal components analysis.

Neuroimaging provides a potential direction in neurobiology providing for functional studies in the central nervous system. Among the multitude of different neuroimaging methods, recording of the intrinsic optical signal (IOS) has a number of advantages. In contrast to other methods, IOS has low invasivity and is economical, though it is highly accurate, which makes it the method of choice for functional mapping in the somatosensory, auditory, and visual areas of the cortex. A limitation of the IOS recording method is its relatively low signal:noise ratio [1, 2], which hinders automatic detection of IOS and its analysis. We have previously demonstrated positive results using temporal and spatial filters to increase the signal:noise ratio [3], though this did not solve the problem of subjectivity in detection of IOS by the operator. Current analytical algorithms for automatic detection include the use of indicator functions, truncated differences, and independent components analysis [4–6]. In addition, these methods are energy-intensive and use extensive computation resources; they were developed for detecting IOS in mature neural tissue. As compared with the adult brain, functional mapping of the brain at its early developmental stages involves a significantly smaller set of techniques for detection of active areas in cortical tissue. Thus, the questions of the use of IOS and means for its detection in the developing brain are currently very relevant. The studies reported here demonstrate that use of principal components analysis (PCA) allows automatic detection of IOS at the level of cortical columns in the barrel cortex of neonatal rats in response to stimulation of the corresponding sensory input. PCA has been shown to be effective despite addition of noise to the initial data making IOS visually undetectable.

The aim of the present work was to assess the potential of using the principal components analysis method for automatic detection of active cortical columns at the early stages of development of the brain in rat pups.

Methods. *Surgery.* All protocols using animal models took account of the methodological recommendations of the French National Institute for Medicine and Health Research (INSERM) (N007.08.01) and the regulations for the use of

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